

SOUTH CAROLINA IRRIGATION GUIDE
CHAPTER 11. IRRIGATION WATER MANAGEMENT

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SOUTH CAROLINA IRRIGATION GUIDE

CHAPTER 11. IRRIGATION WATER MANAGEMENT AND EVALUATION PROCEDURES

GENERAL

Irrigation water management is the act of timing and regulating irrigation water applications in a way that will satisfy the water requirement of the crop without the waste of water, soil, or plant nutrients. It means applying water according to crop needs, in amounts that can be held in the soil and available to crops, and at rates consistent with the intake characteristics of the soil and the erosion hazard of the site.

Management is a prime factor in the success of an irrigation program. The system may be of the best possible design with equipment that is up-to-date and efficient, but success is still not insured.

Labor requirements for a hand-moved irrigation system are large. Often the equipment has to be operated at the same time other labor demands are at their peak. Solid-set and mechanically-moved systems require very little labor. The irrigator must carefully consider how the operation of his type of irrigation system will fit into the total farming enterprise. He must be sure that he has the manpower available for his choice of irrigation system. Good planning and utilization of labor are essential.

Large quantities of water are required for irrigation. Therefore, efficient use of water should be the goal of an adequate program of irrigation system management. Benefits from investments in the irrigation system, labor and irrigation water, are derived from improved quality, yield and marketing advantages that can be achieved from irrigated crops. To obtain these benefits with efficient water use, the irrigator must answer three very pertinent questions: When should I irrigate, how much water should I apply, and is the irrigation system functioning properly?

Man irrigators tend to delay irrigation in hope that rain will come. A cardinal rule of the irrigator must be that he keeps his eyes on the soil and plants and not on the sky. If drainage is adequate, no serious problems should develop should rainfall occur after the completion of proper irrigation.

The question "When should I irrigate?" cannot always be answered precisely. No set rule applies to all situations. Several factors must be considered in each individual case, such as the particular crop, stage of crop growth, minimum practical amount of water to apply, available water supply, irrigation system capacity, and other farm operations schedules.

Most crops should be irrigated by the time that half of the available moisture in the crop root zone has been used. Some crops, however, are thought to do better at higher or lower moisture levels at time of

irrigation than other crops (see Chapter 3, Irrigation Needs of Particular Crops Section). An irrigation may be needed before half of the available moisture has been used. The need for irrigation could be doubtful for any crop until the soil moisture deficit approaches one-third of the available moisture holding capacity of the crop root zone. With these considerations in mind, unless otherwise noted, a good general rule is to commence irrigation for row crops when the soil moisture deficit reaches about the forty percent level for fine to medium textured soils and about fifty percent for moderately coarse to coarse textured soils. Some special purpose irrigations, such as for seed germination, are exceptions to this general rule. Also vegetable crops normally should be irrigated at least by the time 40% of the available moisture is depleted.

It is not always practical and probably not desirable to maintain the same soil moisture level throughout the growing season. Aside from moisture needs to ensure a stand, most crops have critical periods during the growing season when good soil moisture levels must be maintained to obtain high quality yields. The critical period for most crops occurs during the part of the growing season of pod, fruit, tuber, or ear formation and development. Chapter 3, Table 3-2, lists the critical growth periods for a number of important crops.

If sufficient growing season exists for the desired development of the crop, short periods of low moisture during the early part of the growing season may not be harmful except for leaf or forage crops. However over-stimulation of vegetative growth from a combination of high soil fertility and available soil moisture can also be objectionable. This may delay time of harvest enough to miss the period of highest fresh market demand, affect the grade for processing, or cause losses in late maturing crops from frost damage. If irrigation water supplies are limited, the best use of the irrigation water supply would be during the critical growth period of the crop.

Irrigation must begin in time so that the irrigated area can be covered before the available moisture level in the last portion of the field to be irrigated reaches a point to cause unfavorable moisture stress of the crop.

Irrigation schedules often can be varied somewhat to fit other operation schedules. Many times the irrigation system is utilized on a diversity of crops which are at different stages of growth. When the available soil moisture level for each crop area is known, the timing of irrigations can be varied. For example, irrigations of a particular crop may be moved ahead a day or two to facilitate application of insecticides or herbicides.

In determining the need for irrigation one must not overlook the fact that some portions of the field may be drier than others. Poor water distribution during a previous irrigation may cause the soil moisture deficiency in one portion of the field to be considerably greater than in other parts of the field; also, the soil in one part of the field may have less available moisture holding capacity than the soils in

another part. The moisture in this soil might be depleted to the 50 percent level long before the other soils approach that level. If these kinds of critical areas are of significant size, the decision as to when to irrigate should be based on the available moisture in the drier areas.

IRRIGATION EVALUATION

The effectiveness of a farmer's irrigation water management practices can be determined by making field observations and evaluations. These observations and evaluations should also be used to determine if the values and assumptions that were used in the planning and design of the systems conform to the actual field conditions. The results of these observations and evaluations are used to help the irrigator improve his water management techniques and/or upgrade his irrigation system. Procedures for evaluating irrigation systems are not addressed in this chapter but are covered in detail in Appendix B.

IRRIGATION SCHEDULING

The amount of crop evapotranspiration or water requirement varies according to climatic conditions and crop growth stage. The rate of evapotranspiration is much less during the winter season than in the summer. Likewise, the rate is much less when a crop just begins to grow than it is as the crop reaches maturity.

The determination of when and how much to apply requires a knowledge of the available water capacity (AWC) of the soil, the crop rooting depth, the management allowed deficit (MAD) or plant stress level for the specified crop, the crop consumptive use, and the critical periods in the growing season when the crop should not be stressed.

SOIL MOISTURE MEASUREMENTS

The amount of moisture remaining for crop use is found by making soil moisture measurements. The moisture level can be estimated by the feel and appearance method, as well as by various soil moisture measuring devices. Moisture measurements can be used alone for scheduling irrigations, but usually are used in combination with consumptive use prediction methods to reduce the number of moisture measurements needed.

Also, one or more days lead time may be needed by the irrigator to plan farming operations or make other management decisions prior to irrigating. He may not be able to wait until a moisture measurement reveals it is time to irrigate.

The consumptive use information in Chapter 4 can be used for reasonable estimates of the rate the crop is using moisture. If the rate of crop moisture use and the amount of soil moisture remaining are known, the date irrigation is needed can be predicted.

Soil moisture measurements should be made from the part of the soil from which plant roots extract their moisture and according to the moisture-extraction pattern of the particular crop. Regardless of the moisture measurement method used, the sampling procedures and selection of the moisture measuring stations are important.

Sampling Procedures

The sampling procedure should be as follows:

1. In uniformly textured soils, one measurement should be made at the midpoint in each quarter of the root zone. For shallow rooted crops it is probably desirable to take three measurements. As an example, in a 24-inch zone, measurements may be taken from the 6-, 12-, and 18-inch depth.
2. In stratified soils, one measurement should be taken from each textural strata. It may not be necessary to take a measurement in very thin layers when this thin layer can be lumped with another layer from estimating soil moisture. Where the strata is thick a sample should be taken in 1-foot increments as a minimum. Thickness of the strata should be noted.
3. The crop root depth for annual crops changes through the early part of the growing season. Measurements should be made in the soil profile according to the current depth of the majority of the crop roots.

Selection of Moisture Measuring Station

The selection of soil moisture measurement stations is important. The stations should be located so that average soil moisture conditions in the root zone of the crop are measured. Excess water from leaks in pipe joints, low spots in a field, etc., should not be allowed to come in contact with the measurement station. High spots with excessive water runoff should not be chosen because the soil profile in this area will not represent average root zone conditions. Average soil and slope conditions in the field should be represented in station locations. Measurements should be made at other locations as indicated by any

critical condition in the soil, such as an area that dries out first. It is good practice to have at least two measurement stations in each critical area and two or three stations in areas that are typical of the field. This information provides direction for adjusting the amount and frequency of irrigation for different parts of the field or for different periods in the growing season.

1. Location in relation to plants.

- a. Row crops - locate in the crop row as near the plants as possible.
- b. Mature trees - located 8 to 10 feet from the trunk for pecans and 4 to 6 feet from the trunk for peaches and apples but inside the tree drip line; and
- c. Crops with complete cover such as alfalfa and grains - locate in representative soil and slope areas of the field.

2. Location in relation to irrigation systems.

- a. Lateral move sprinklers such as side roll or hand move aluminum pipe - locate measurement stations halfway between adjacent sprinkler heads and 10 to 15 feet from the lateral.
- b. Center pivot sprinklers - locate measurement stations at about two-thirds of the total lateral distance from the pivot.
- c. Traveling gun sprinklers - locate measurement stations midway between towpaths.
- d. Solid set sprinklers - locate measurement stations where the diagonals from four adjacent sprinkler heads cross.
- e. Trickle systems - locate in the wetted ball in the root zone.

3. Location in field for sprinkler or trickle irrigation systems. Sprinkler and trickle irrigation systems generally lose pressure down the lateral due to friction loss throughout the lateral so sprinkler heads farthest from the main lines put out the least irrigation water. To check adequacy of irrigations, locate measurement stations as follows:

- a. 50 to 100 feet downstream from the beginning of the lateral.
- b. 50 to 100 feet upstream from the distant end of the lateral.

MEASURING SOIL MOISTURE

Irrigation water management requires that soil moisture measurements be made to determine the amount of soil moisture available to the plants. Numerous techniques have been developed to obtain this information. A brief discussion of the more common methods follows. More detailed information can be found in Appendix A.

Feel and Appearance Method

With experience, an irrigator can achieve adequate accuracy by using the simple feel and appearance method to judge soil water content. Soil augers or probes are used to obtain soil samples down through the root zone of the crop. The percent of available moisture remaining is estimated by observing the feel and appearance while manipulating the sample according to a guide table (see Appendix A). The equipment required is simple and easily obtained, but requires time and effort to obtain reliable results. An added benefit of this method is that the irrigator actually observes his soil profile and gains a better knowledge of the soil-plant-water relationship.

Gravimetric Method

The gravimetric method or oven dry method is the most accurate, but requires much time and effort to obtain the data. Soil samples are collected in the field and then oven dried in a lab. Moisture proof sample containers, a beam balance, drying oven (microwave can be used and reduce time needed to dry soil) and core samples are necessary equipment. This method gives the percent of total moisture in the soil, which must be converted to plant available moisture. It is used primarily for evaluation and research data and for calibrating other devices.

Tensiometers

Tensiometers measure soil moisture suction. They are a closed tube with a hollow ceramic tip at the soil contact end and a vacuum gage on the above ground end. It is filled with water and installed in the soil. As the soil dries, it pulls water through the ceramic tip, creating a vacuum inside the tensiometer. As the soil is wetted again from irrigation or rain, water is pulled back into the tensiometer, thus lowering the reading on the vacuum gage.

Most tensiometer gages read from 0 to 100 in centibars. One hundred centibars equal one bar, which is about the same as one atmosphere. A tensiometer can operate on the range of 0 to 80 centibars. A reading of 0 indicates a saturated soil. Different soil textures release water at different soil moisture tensions and, therefore, different tensiometer values. Readings of about 10 and 25 represent field capacity and ideal moisture aeration conditions respectively for sandy soils. Readings of about 30 to 60 represent corresponding conditions in clay soils.

Other soil texture combinations would utilize tensiometer values somewhere between these values for sand and clay soils. The wilting point occurs in the 1000 to 2000 centibar range which is well beyond the operating range of tensiometers.

Of the total water released by a soil between field capacity and the wilting point, the percentage released within the tensiometer measuring range may be as high as 90 percent for a sandy soil and as low as 30 percent for a clay soil. Tensiometers are best suited for soils that release 50 percent or more of their available water in the tensiometer range, 0 to 80 centibars.

Tensiometer readings tell when to irrigate, but do not tell how much to apply. Calibration curves are needed to relate soil tension to available moisture percentage (see Chapter 3, Irrigation and Crop Production Section, for general relationship and Appendix A).

Electrical Resistance Blocks

This method is based on the changes of electrical resistance of the blocks due to change in moisture contents. The blocks are buried in the soil, a change in the soil moisture makes a corresponding change in the moisture of the blocks. The electrodes in the blocks are connected by wires to the surface that can be connected to a portable resistance meter. Any change in the resistance of the blocks is an indirect measurement of the change of soil moisture tension. The reading can be calibrated in terms of percent moisture, but must be calibrated for specific soils. Resistance blocks are less sensitive than tensiometers in the range of 0 to 80 centibar range, but can operate in the range of field capacity to wilting point.

A special electrical resistance block is available that is as sensitive as a tensiometer, but will not have the high maintenance characteristics in the high tension region above 80 centibar.

SOIL MOISTURE COMPUTATIONS-DETERMINING WHEN AND HOW MUCH TO APPLY

General

Regardless of the method used to measure soil moisture, it should either provide the answer on percent of plant available moisture remaining or have curves to convert to percent of available moisture. Appendix A shows the method used to convert the soil moisture measurement to percent of available moisture remaining for each of the soil moisture measurement methods discussed above.

Root Zone Water Balance

The minimum root zone moisture balance to be maintained is dependent upon the current rooting depth, AWC of the soil and the MAD (based on the crop's characteristics). For example, with an AWC of 2.2 in. for the rooting depth and a MAP of 40%, the minimum root zone balance to be maintained is 1.32 in. (2.2 in. x 0.60).

Computer programs are in use that estimate crop water usage from actual climatological data and maintain a current root zone water balance. They also predict crop water requirements, date of irrigation, and compute net irrigation requirements. The water balance computations are normally begun from initial soil moisture measurements. Subsequent measurements are also needed to verify predicted deficits. As discrepancies develop, the necessary corrections are made. These services may be available from commercial management firms that provide the irrigator weekly printouts containing scheduling information.

Farmers can also keep their own root zone water balance records. They will need to make soil moisture measurements to determine the initial soil moisture content and balance, as well as occasional measurements during the growing season to verify the computations. A rain gage will be needed to record the rainfall. Estimated crop water use the needs are provided by various means. It may be provided on a current basis through the local news media by a public agency or irrigation group using actual climatological data on a computer program. Seasonal data may also be available using normal climatological data from a local weather station. The consumptive use data in Chapter 4 of this guide can also be used.

Figure 11-1 illustrates one method that can be used to obtain estimated crop water use for scheduling irrigations. This method uses the consumptive use data contained in Chapter 4, Table 4-2, and is a plot of average daily consumptive use versus time. The curve is constructed by taking the monthly consumptive use and dividing by the number of days within the month (or part of month) and plotting this point at the midpoint of the month (or midpoint of the part month). This is done for each month of data. The point for the peak use period may be approximated by using the recommended design peak from table 4-1 of Chapter 4. When all the points are plotted a smooth curve is drawn connecting the points. In Figure 11-1 the monthly consumptive use curve was plotted for corn grown in climatic zone 2. From Table 4-2, the consumptive use for May is 5.99 inches or 0.19 in./day (5.99 inches ÷ 31 days) average. This was plotted

AVERAGE DAILY CONSUMPTIVE USE CURVE FOR CORN CLIMATIC ZONE 2

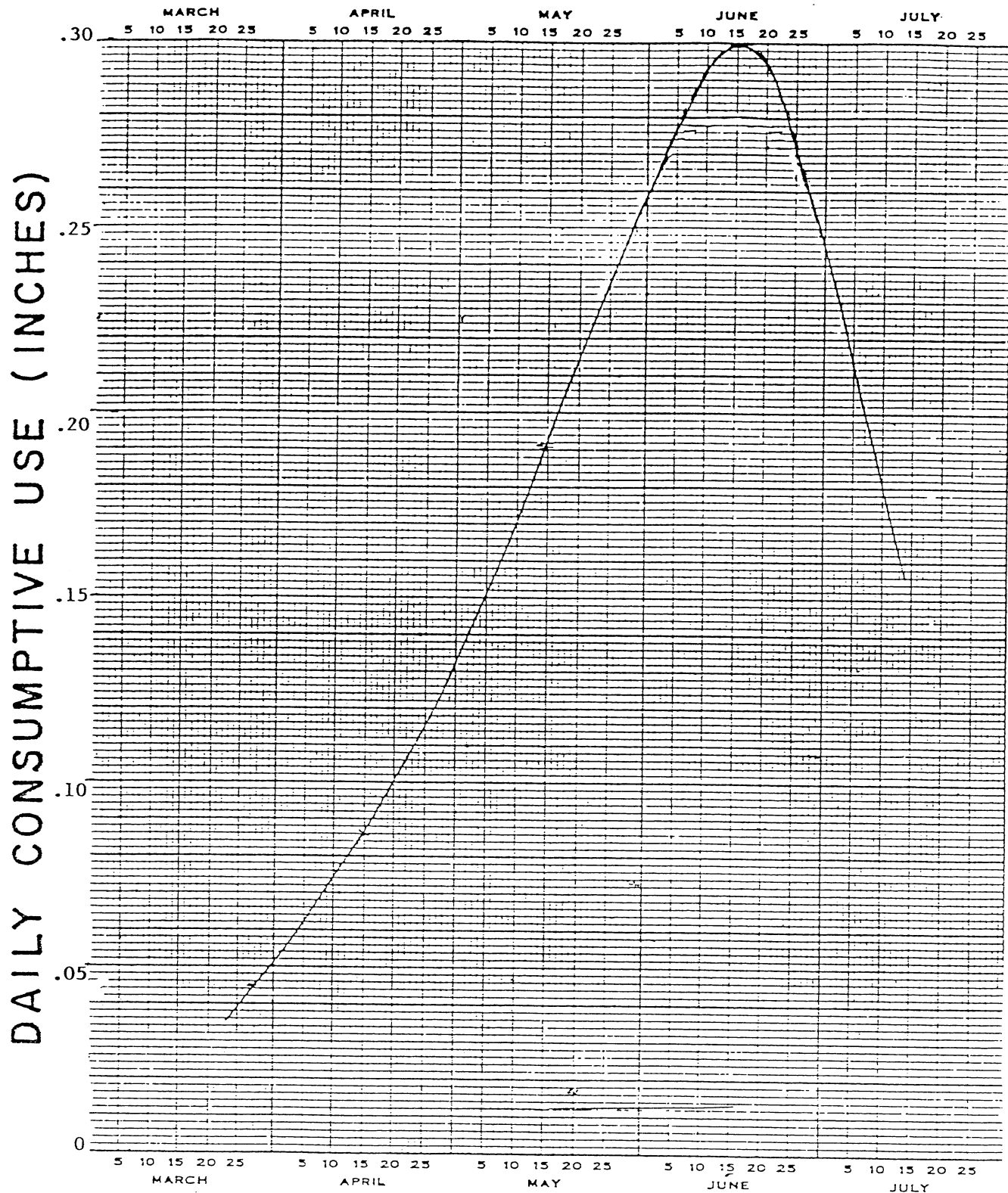


FIGURE 11-1

on the graph at the middle of May. For June, the consumptive use is 6.98 inches or 0.23 in./day ($6.98 \text{ inches} \div 30 \text{ days}$) average. Since this is the peak use month, the peak value can be estimated by using the design peak from Chapter 4 of this Guide (0.3 in./day). This was plotted on the graph at the middle of June. Points were plotted for each month and the curve drawn connecting the points. The average daily consumptive use can be taken from the graph by projecting vertically from the day of the month in question until intersecting the curve and then projecting horizontally to read the consumptive use. For example, on May 5 the estimated consumptive use is 0.15 in./day.

Moisture Accounting Method of Scheduling

Once the consumptive use data and actual rainfall is obtained, the irrigator can schedule irrigations using the moisture accounting method. Figure 11-2 illustrates the accounting method for corn grown in climatic zone 2 for one month of the crop's growing season. Similar sheets would need be prepared for each month of the growing season. At the beginning of the season, moisture measurements should be taken and the moisture content determined. Moisture measurements should also be taken periodically during the growing season to verify soil moisture content or make adjustments as necessary. The example in Figure 11-2 shows that the AWC of the soil is 1.66 inches. With a MAD of 40%, irrigation is needed when the root zone moisture balance is 1.00 in. [$(1.66 \text{ in.} - (0.40)(1.66 \text{ in.}))$]. The example shows a balance from the previous month of 1.50 inches. Knowing the balance, it is a matter of subtracting the estimated consumptive use and adding any effective rainfall and/or irrigation. The account is kept on a daily basis. The estimated consumptive use in this example is taken from Figure 11-1. The rainfall can be measured using rain gages. It must be remembered that all rainfall is not effective. The rainfall may exceed the amount needed to fill the root zone to field capacity resulting in some of it lost to deep percolation or runoff. For example, referring to Figure 11-2, on May 8 a 1.5 inch rain occurred but the amount needed to refill the root zone was only 0.63 inches ($1.66 \text{ in.} - 1.03 \text{ in.}$). Therefore, .87 inches was not effective ($1.50 \text{ in.} - 0.63 \text{ in.}$).

Figure 11-2. Moisture Balance Sheet for
Scheduling Irrigation

Farm J. Doc Field No. 1 Crop Corn Month May Year 1986
County Orangeburg Climatic Zone 2 Soil Type Goldshero
Moisture Holding Capacity in Root Zone 1.66 inches
Net Moisture to Apply at Each Irrigation ≈ 0.7 inches
Irrigate when balance is 1.0 inches

Date	Estimated Daily Consumptive Use, inches	Rainfall inches	Net Irrigation inches	Daily Balance Inches	Remarks
Balance brought forward				1.50	Bal. brought forward from previous day
1	0.14			1.36	
2	.14			1.22	
	.14			1.08	
4	.15		0.73	1.66	Irrigate
	.15			1.51	
6	.15			1.36	
	.16			1.20	
8	.17	1.5		1.66	Rain replenished
	.17			1.49	
10	.17			1.32	
	.18			1.14	
12	.18		0.70	1.66	Irrig.
	.18			1.48	
14	.19			1.29	
	.19			1.10	
16	.20		0.76	1.66	Irrig.
	.20			1.46	
18	.20			1.26	
	.21			1.05	
20	.21		0.82	1.66	Irrig.
	.22			1.44	
22	.22			1.22	
	.23	0.8		1.66	
24	.23			1.43	
	.24			1.19	
26	.24		0.71	1.66	Irrig.
	.24	1.2		1.66	
28	.25			1.41	
	.25			1.16	
30	.25	1.0		1.66	
31	.26			1.40	
TOTALS	6.1		3.72		

Tensionmeter Method of Scheduling

Detailed information concerning use of tensionmeters for scheduling irrigation is given in Appendix A. Tensionmeters are suited for use in medium and coarse textured soils in the active root zone. Tensionmeters placed at shallow and deep depths as per Table A-2 (Appendix A) may be used to indicate when to begin and end irrigation respectively.

Pan Evaporation Method of Scheduling 1/

Evaporation from an open or screen-covered pan can be used to schedule irrigation in either of two methods. The daily pan evaporation value can be used to estimate potential evapotranspiration (ET_p) in a water balance procedure. Based upon research results at Florence, South Carolina, evaporation from a screen-covered pan is approximately 0.87 open pan evaporation and can be used to directly estimate ET_p . If open-pan evaporation is used, the values must be adjusted to estimate ET_p . The second method for using an evaporation pan to schedule irrigation is to modify the pan so that it can be used to physically simulate ET_p on a daily basis. Due to the combined simplicity and reliability of this method, it has much potential for on-farm use and is described below.

Modifications include the installation of an overflow device to remove excess water and a rustproof (stainless steel, brass, etc.) measuring scale to measure water level in a standard National Weather Service Class A evaporation pan. The overflow should be set so that the pan will fill to within 1-2 inches of the top edge of the pan before excess water is removed. The measuring scale should be mounted securely in the vertical position (e.g., to the side of the pan using a clamping device) so that it can be adjusted to place the scale reference point at the water surface when the pan is full (overflowing).

The amount of water that can be depleted from the soil profile before irrigation is initiated is dependent upon several factors, all determined by the specific site. Also, three assumptions required when using this method to schedule irrigation are that (1) pan evaporation is equal to ET_p , (2) all rainfall and irrigation infiltrates the soil, and (3) water from rainfall and irrigation in excess of soil storage is lost either as runoff or deep percolation. Rooting depth, irrigation system efficiency, water storage capacity of the soil, and the fraction of water stored in the soil profile that can be depleted before irrigation is initiated (allowable depletion) must be known before the scale-setting calculation can be made. Details of the calculation of this value can best be explained through the use of an example.

Assume a center pivot system with an application efficiency of 80% is used to irrigate corn in an area which includes three soil types in the proportion indicated: Raines, 10%; Norfolk, 40%; and Wagram, 50%. Assume the moisture control zone for corn is estimated to be 24 inches, and irrigation is to be applied when 40% of the available water in the rooting zone is depleted. Available water capacity for the soil may be calculated using published SCS data for the individual soils. Assume the available water stored in the 24-inch rooting zone for the Norfolk, Wagram, and Raines soils is 2.3, 1.8, and 2.7 inches, respectively. This information can be used in several different ways to estimate a representative value for available water stored

| 1/ By C. R. Camp and C. W. Doty with modifications by SCS. |

in the soil profile under this center pivot system. Simple or weighted means of the three values are two obvious methods. A more conservative approach would be to use the value for the Wagram soil since it has the lowest storage value and comprises 50% of the area. One potential danger in this approach is that the other soils might become too wet if significant rainfall immediately follows irrigation, but the maximum difference in storage among these soils at the 50% level is only 0.45 inches, which is only a 1- or 2- day difference in irrigation timing. Available water stored in the soil profile may be calculated several times during the growing season, if desired, to reflect the changing rooting depth.

The amount of water to be applied at each irrigation is determined by the relationship, $I = (AW)(AD)/E$ where I is the amount of irrigation water to be applied, AW is the volume of available water in the rooting zone, AD is the allowable depletion (fraction of available water to be used by the crop before irrigation is applied), and E is the irrigation system efficiency expressed as a fraction. For this case, $I = (1.8)(0.5)/0.8 = 1.12$ inches.

The amount of pan evaporation required before irrigation is initiated is determined by the equation, $PE = (AW)(AD)/C$, where PE is pan evaporation required before irrigation is initiated, C is a crop coefficient relating ET to ETp, and other variables are as defined earlier. Recommended values of C are given below. For this example, using a C value of 1, $PE = 1.8(0.5)/1.0 = 0.9$ inches

<u>Crop</u>	<u>Crop Stage</u>	<u>Crop Coefficient (C) for Screened Pan</u>
Corn	Emergence to 20 inch height	0.61/
	20 inch height to maturity	1.01/
Cotton	1st bloom to boll maturity	1.0
Soybeans	Emergence to canopy closure	-
	canopy closure to maturity	1.01/
Peanuts	1st bloom to nut maturity	0.8
Snap beans	0 to 20 days from emergence	0.52/
	21 to 30 days from emergence	0.62/
	31 to 40 days from emergence	0.72/
	41 to 50 days from emergence	0.82/
	51 to 60 days from emergence	0.92/

The evaporation pan simulator should be initialized when soil water storage is maximum, one or two days after rainfall or irrigation that filled the soil profile. The pan should be leveled, filled with water until it overflows, and allowed to reach equilibrium. The metal scale is then inserted into the water to the depth of allowed depletion calculated for the pan (0.9 inches for this example), and securely clamped or fastened to the side of the pan. The water depth and scale reading should be observed daily. When the water level reaches the scale zero (or 0.9 inches, in this

example, if the scale was installed with zero at the original water surface), irrigation should be initiated. If the total amount of depleted water is not replaced by irrigation (partial or reduced irrigation), the depth of irrigation water actually applied (measured, if possible) is then added to the pan. If the total amount of depleted water is replaced by irrigation, water can be added to the pan until it overflows. For sprinkler irrigation systems, the pan may be placed under the irrigation system where it will receive the irrigation applied. If this is not possible, water must be added to the pan after each irrigation. When rainfall occurs, water level in the pan will rise proportionally, reflecting the increase in available water. Rainfall in excess of storage will be lost from the pan via the overflow. The evaporation pan simulator will operate in a similar manner for the entire season.

The pans used in research are stainless steel like those used by the National Weather Service and may cost several hundred dollars. Irrigators may make their own from a barrel or large galvanized tub. The pan, tube, or barrel should be about 2 feet or more in diameter and deep enough to hold at least a foot of water. This volume is needed to keep the water from heating up too much. Chicken wire should be secured over the top to keep wildlife out and will reduce evaporation by about 12 percent.

Household bleach may be added to the container to help keep water free of scum or algae.

- 1/ Doty, C.W., C.R. Camp, and G. D. Christenbury. 1982. Scheduling irrigation in the Southeast with a screened evaporation pan. Proc. Speciality Conf. on Environmentally South Water and Soil Management, Am. Soc. Civil Engr., Orlando, FL, July 20-23.
- 2/ Smittle and Stansel - Scheduling Snap Bean Irr. From Pan Evaporation Data, Tifton Ga., approx. 1981.
- 3/ Campbell, R. B. and C. J. Phene. 1976. Estimating potential evaporation from screened pan evaporation. Agric. Meteorol. 16:343-352

IRRIGATION WATER MANAGEMENT PLAN

GENERAL

An irrigation water management plan is an essential part of the conservation irrigation plan. See Chapter 7 for explanation and contents of an irrigation water management plan. Irrigation water management plans should be tailored to the individual site and the management expertise and desires of the irrigator.

CRITERIA

General requirements for an irrigation water management plan are contained in the SCS Technical Guide, Irrigation Water Management, Std. 449.

EXAMPLE IRRIGATION WATER MANAGEMENT PLAN

The following example is intended to cover the basic steps to follow in the development of an irrigation water management plan. An example irrigation water management plan is shown in Exhibit 11-1.

Given:

Develop an irrigation water management plan for the center pivot system in Chapter 10-C of this guide.

Solution:

- Step 1. Provide the irrigator basic data such as: acres to be irrigated of each crop, water supply, irrigation flow rates, water quality, soil type, AWC, MAD, peak consumptive use rate, intake rate, irrigation efficiency, and rooting depth (water control zone). This data is contained in the irrigation data sheets as shown in Chapter 10-C. In this example, information would be provided to the irrigator by giving him a copy of the Irrigation Data Sheets 1-5.
- Step 2. The various methods available to monitor or determine soil moisture should be discussed with the irrigator in such detail that he can select a method to use. Once he chooses a method, then work with him until he understands how to use the method. The irrigator in this example selected the feel and appearance method of determining soil moisture content along with tensiometers. The irrigator should be able to convert the soil moisture measurement to inches of water available to the crop. A form for converting soil moisture measurement to AWC was included in the irrigation water management plan Exhibit 11-1, sheet 1 of 6.

Appendix A shows how to convert the soil moisture measurement to AWC in inches for the major soil moisture measurement methods.

- Step 3. Provide the irrigator with information on the crop water requirements - daily, monthly, and seasonal. These can be approximated by using computed values from Chapter 4 of this guide with the planting and harvest dates shown that are close to the actual dates. This example is for grain corn in climatic zone 2. This data would be given to the irrigator and is shown on Exhibit 11-1, sheet 2 of 6. The irrigator should have an understanding that this information is estimated. Also he should have an understanding of effective rainfall (i.e., that all rainfall is not available for the crop).

- Step 4. The irrigator should have a method to determine when to irrigate (i.e., an irrigation scheduling procedure). The different methods should be explained to the irrigator in such detail that he can select a method. Once the irrigator has selected a method to use in scheduling irrigations, he should be taught how to use it. In this example, the irrigator selected to use the tensionmeter method. Needed information would be prepared for the irrigator and included in the irrigation water management plan, Exhibit 11-1, sheet 3 of 6.
- Step 5. The critical stages of growth where sufficient moisture is necessary for crop production should be provided to the irrigator. The information can be obtained from Chapter 3, Table 3-2, of this guide. The critical periods for corn were included in the irrigation water management plan, Exhibit 11-1, sheet 4 of 6.
- Step 6. The irrigator should know how much to apply. The net amount to apply for this example was determined by the feel and appearance method of estimating the AWC and MAD and will vary at different rooting depths (i.e., crop growth stages). The gross amount to apply is the net amount divided by the irrigation system efficiency. The irrigator should understand that the irrigation system is not 100% efficient in delivering water to the field and that he should divide the net amount by the irrigation efficiency to obtain the gross amount to apply. Irrigation efficiency was given on the irrigation data sheets as 70 percent.

The irrigator should know the application rate of his irrigation system (in./hr) in order to determine the time needed to apply the required water. In the case of self-propelled irrigation equipment, operating adjustments should be made to apply the necessary irrigation amount. For center pivot systems a table should be developed to relate the dial setting to the gross water applied. Chapter 10-C of this guide gives a procedure for determining gross application of center pivot systems. The dial setting for this system was computed and included in the irrigation water management plan, Exhibit 11-1, sheet 4 of 6, showing the gross amount and net amount applied.

- Step 7. The irrigator should be taught how to recognize erosion caused by irrigation and excess runoff of irrigation water and should be provided ways to make adjustments to prevent runoff. The information provided will vary with each situation due to the variance in erosion potential of soils, land slope, soil intake rate, etc. A statement was made for this example and included in the irrigation water management plan, Exhibit 11-1, sheet 4 of 6.
- Step 8. The irrigator should be provided a method of evaluating the performance of his irrigation applications. This would consist of explaining the reasons to evaluate the system and forms that would be helpful in evaluating the system. It may be necessary to work with the landowner on the first evaluation to teach him how to gather and interpret the data. In this example, forms were included in the irrigation water management plan, Exhibit 11-1, sheets 5 of 6 and 6 of 6. Plans were made to assist the irrigator in evaluating his irrigation system. Appendix B gives information on how to evaluate irrigation systems.

Exhibit 11-1

IRRIGATION WATER MANAGEMENT PLAN

Cooperator: Bill JonesField No. 3Sheet 1 of 6Location: Orangeburg Co.

1. Format for figuring the net amount of water needed for an irrigation using the feel and appearance method of soil moisture measurements.

(1)	(2)	(3)	(4)	(5)	(6)
Depth	Soil Series	Available water capacity	Soil water content before irrigation		Soil water deficiency
(feet)	(texture)	(inches)	(percent)	(inches)	(inches)
<u>0-1.5</u>	<u>Fuquay</u> <u>Loamy Sand</u>	<u>0.90</u>	<u>50</u>	<u>0.45</u>	<u>0.45</u>
<u>0-2.0</u>	<u>" "</u>	<u>1.20</u>	<u>50</u>	<u>0.60</u>	<u>0.60</u>

Column 1, the depth increment sampled.

Column 2, the soil texture of the sample.

Column 3, the available water capacity based on the texture of the sample.
AWC (inches) = depth (inches) x AWC (in./in.)

Column 4, the percent of soil water content (remaining).

0-25% AWC - Dry, loose, flows through fingers.

25-50% AWC - Looks dry, will not form ball with pressure.

50-75% AWC - Will form loose ball under pressure, will not hold together even with easy handling.

75-100% AWC - Forms weak ball, breaks easily, will not "slick."

Column 5, Column 3 x Column 4, the soil-moisture balance, inches.

Column 6, Column 3 - Column 5, soil-moisture deficiency or net irrigation requirement.

2. Alternate format for figuring the net amount of water needed for an irrigation using soil water tension versus water content (average values obtained from table 2-1 for coastal plain soils).

Estimated soil moisture content @ 0.10 bar tensiometer reading = .13 in./in.

Estimated soil moisture content @ 0.30 bar tensiometer reading = .10 in./in.

For early to mid-season corn, net amt. to irrigate = 18" depth x .03 = 0.54"

For mid to late season corn, net amt. to irrigate = 24" depth x .03 = 0.72"

Exhibit 11-1

Sheet 2 of 6

Crop - Corn, Grain

Moisture Allowed Deficiency (MAD) = 50%

Approx. Planting Date - March 20

Approx. Maturity Date - July 8

<u>Month</u>	<u>Estimated Consumptive Use - inches</u>	<u>Estimated Accumulated Consumptive Use - inches</u>
March	0.4	0.4
April	2.6	3.0
May	6.0	9.0
June	7.0	16.0
July	1.8	17.8

Exhibit 11-1

IRRIGATION SCHEDULING INFORMATION

Crop - Corn

Soil - Fuquay Loamy Sand

Method - Tensiometers

Number of Tensiometers - 2 each at three locations as shown on Plan Map (place in the crop rows).

Tensiometers should be placed as follows:

<u>Time of Season</u>	<u>Estimated Depth of Water Con- trol Zone</u>	<u>Recommended depths of setting Tensiometers</u>		<u>Estimated net water to apply Initially^{1/}</u>
		<u>Shallow</u>	<u>Deep</u>	
Early to mid- season (corn generally less than 3' high)	18"	8"	12"	0.45
Mid-to late season	24"	12"	18"	0.6

Begin irrigation when shallow tensiometer reads 30 centibars (.3 bars). After the initial application, vary the application amount as needed so that the deep tensionmeter reading drops to about 10 centibars (.10 bars) within 1 to 12 hours afterwards.

^{1/} Value given for net water to apply is for estimating purposes only based upon the feel and appearance method of estimating soil moisture as given on p. 1 of 6. Install tensiometers and service at regular intervals as recommended by mfg.

Exhibit 11-1
IRRIGATION WATER MANAGEMENT PLAN

CRITICAL GROWTH STAGE

Demand for water is especially high and important during the tasseling and grain filling period. The grain filling period is the 3 weeks following tasseling.

Corn should never be allowed to wilt appreciably. If limited irrigation is necessary, the critical period for irrigation is from the tassel stage through grain filling.

IRRIGATION APPLICATION

Irrigation to be Applied, Inches		Time Required per Revolution-Hours	Dial Setting
Net	Gross (@ 70% efficiency)		
.21	0.30	15.4	100
.24	.34	17.1	90
.27	.38	19.2	80
.31	.44	22.0	70
.36	.51	25.7	60
.43	.61	30.8	50
.53	.76	38.5	40
.71	1.02	51.3	30
1.06	1.52	77.0	20
2.14	3.05	154.0	10

EROSION OR EXCESS IRRIGATION RUNOFF

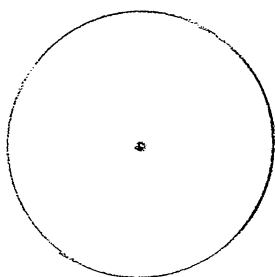
Soil intake rate can change. The intake rate will usually decrease the longer the irrigation time (i.e., during the lower dial settings). Visual observations should be made to determine if erosion or excess runoff occurs. Appropriate adjustments in the irrigation system operation or other conservation practices should be applied to reduce erosion and runoff as needed.

Exhibit 11-1
IRRIGATION WATER MANAGEMENT PLAN

CENTER PIVOT SPRINKLE IRRIGATION EVALUATION

1. Location _____, Observer _____, Date & Time _____
2. Equipment: make _____, length _____ ft, pipe diameter _____ in
3. Drive: type _____ speed setting _____ %, water distributed? _____
4. Irrigated area = $\frac{3.14 (\text{wetted radius } \text{ft})^2}{43,560}$ = _____ acres

5. N wind



*Mark position of lateral direction of travel, elevation differences, wet or dry spots and wind direction.
Wind _____ mph, Temperature _____ °F

Pressure: at pivot _____ psi
at nozzle end _____ psi
Diameter of largest nozzle _____ in

Comments: _____

6. Crop: condition _____, root depth _____ ft
7. Soil: texture _____, tilth _____, avail. moisture _____ in./ft.
8. SMD: near pivot _____ in, at 3/4 point _____ in, at end _____ in.
9. Surface runoff conditions at 3/4 point _____, and at end _____
10. Speed of outer drive unit _____ ft per _____ min = _____ ft/min
11. Time per revolution = $\frac{(\text{outer drive unit radius } \text{ft})}{9.55 (\text{speed } \text{ft/min})}$ = _____ hr
12. Outer end: water pattern width _____ ft, watering time _____ min
13. Discharge from end drive motor _____ gal per _____ min = _____ gpm
14. System flow meter _____ gallons per _____ min = _____ gpm
15. Average weighted catches:
System = $\frac{(\text{sum all weighted catches})}{(\text{sum all used position numbers})}$ = _____ ml = _____ in
Low 1/4 = $\frac{(\text{sum low 1/4 weighted catches})}{(\text{sum low 1/4 position numbers})}$ = _____ ml = _____ in
16. Minimum daily (average daily weighted low 1/4) catch:
 $\frac{(\text{hrs operation/day}) \times (\text{low 1/4 catch } \text{in})}{(\text{hrs/revolution})}$ = _____ in/day

Exhibit 11-1

IRRIGATION WATER MANAGEMENT PLAN

CENTER PIVOT SPRINKLE IRRIGATION EVALUATION (Cont.)

17. Container catch data in units of _____, Volume/depth _____ ml/in
 Span length _____ ft, Container spacing _____ ft
 Evaporation: initial _____ ml _____ ml
 final _____ ml _____ ml
 loss _____ ml _____ ml, ave _____ ml = _____ in

Span no.	Container			Span No.	Container		
	Position Number	X Catch =	Weighted Catch		Position Number	X Catch =	Weighted Catch
	1				37		
	2				38		
	3				39		
	4				40		
	5				41		
	6				42		
	7				43		
	8				44		
	9				45		
	10				46		
	11				47		
	12				48		
	13				49		
	14				50		
	15				51		
	16				52		
	17				53		
	18				54		
	19				55		
	20				56		
	21				57		
	22				58		
	23				59		
	24				60		
	25				61		
	26				62		
	27				63		
	28				64		
	29				65		
	30				66		
	31				67		
	32				68		
	33				69		
	34				70		
	35				71		
	36				72		

Sum all: used position numbers _____, weighted catches _____

Sum low 1/4: position numbers _____, weighted catches _____